STATION PAPER NO. 100
MAY 1962

Identification of Conifer Insects by Type of Tree Injury, Lake States

H. J. MacAloney
and
D. C. Schmiege

LAKE STATES FOREST EXPERIMENT STATION
and
NORTH CENTRAL REGION
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE

FOREWORD

In the U. S. Forest Service, responsibilities for forest insect surveys and research are assigned respectively to the North Central Regional Office and the Lake States Forest Experiment Station. The Region conducts detection and evaluation surveys of insect infestations, initiates control measures on National Forests, and provides technical assistance on control programs to private, State, and other Federal land-managing groups when appraisals indicate that control measures are justified. The Station conducts research on the biology, ecology, and control of insects and on survey techniques. Results of research are published periodically and are summarized in the Station's annual report.

This publication was prepared by the Station, and publication costs were shared by the Region. A number of staff members participated in assembling the material. The primary objective is to assist forest managers in identifying forest insects. It is believed that prompt and correct identification and reporting of forest insects can do much to indicate the location of specific areas that are infested and the need for applying control measures.

Cover picture: A posthorn in red pine created by the European pine shoot moth. The insect kills the terminal bud and a lateral takes over (F-490260).

Station Paper No. 100

May 1962

Identification of Conifer Insects by Type of Tree Injury, Lake States

by

H. J. MacAloney and D. C. Schmiege
Forest Entomologists

Lake States Forest Experiment Station*

and

The North Central Region

Forest Service

U. S. Department of Agriculture

*Maintained at St. Paul 1, Minn., in cooperation with University of Minnesota.

CONTENTS

Page

Introduction 1

Key based on type of tree injury 2

Defoliators 7

Sawflies 7
(Illustrations of the larvae and information on the life cycle of 15 sawfly species appear on the centerfold.)
Needle Miners 10
Larch casebearer (*Coleophora laricella*) 10
Spruce needle miner (*Evagora piceaella, Epinotia nanana, Taniva albolineana*) 10
Pine needle miners 11
Budworms 11
Spruce budworm (*Choristoneura fumiferana*) 11
Jack-pine budworm (*Choristoneura pinus*) 11
Pine chafer 13
Pine chafer or Anomala beetle (*Anomala oblivia*) 13
Tussock moth 13
Pine tussock moth (*Dasychira plagiata*) 13

Sucking insects 14
Scale insects 14
Pine tortoise scale (*Toumeyella numismaticum*) 14
Pine needle scale (*Phenacaspis pinifoliae*) 14
Black pine leaf scale (*Aspidiotus californicus*) 15
Aphids 16
Eastern spruce gall aphid (*Chermes abietis*) 16
Pine leaf aphid (*Pineus pinifoliae*) 17
Pine bark aphid (*Pineus strobi*) 18
Spittlebugs 19
Saratoga spittlebug (*Aphrophora saratogensis*) 19
Pine spittlebug (*Aphrophora parallela*) 22
Midges 22
Pitch pine midge (*Retinodiplosis resinicola*) 22
Spruce gall midge (*Phytophaga piceae*) 23

Bud, shoot, stem, and root insects 24
Caterpillars 24
European pine shoot moth (*Rhyacionia buoliana*) 24
Pitch-nodule maker or pitch-blister moth (*Petrova albicapitana*) 25
Zimmerman pine moth (*Dioryctria zimmermani*) 25
Western pine tip moth (*Rhyacionia frustrana* variety *bushnelli*) 26
Other tip moths 26
Jack-pine shoot borer (*Eucosma sonomana*) 27
Pitch mass borer (*Vespamima pini*) 28
Weevils 29
White-pine weevil (*Pissodes strobi*) 29
Northern pine weevil (*Pissodes approximatus*) 30
Pine root collar weevil (*Hylobius radicis*) 31
Pales weevil (*Hylobius pales*) 32
Pine gall weevil (*Podapion gallicola*) 33
Strawberry root weevil (*Brachyrhinus ovatus*) 33
Black vine weevil (*Brachyrhinus sulcatus*) 34
Bark beetles 34
Woodborers 35
White grubs 36

Injurious species not yet recorded 37
Black-headed budworm (*Acleris variana*) 38
Red pine scale (*Matsucoccus resinosae*) 38
Balsam woolly aphid (*Adelges piceae*) 39

Bibliography 40

INTRODUCTION

Insects are a serious threat to the production of timber and other wood products in the Lake States. Many of these pests are native. Others have inadvertently been introduced. Both groups have often been extremely destructive to the forests.

The forest history of the Lake States is similar to that of many other regions of the country. Extensive stands of second growth followed the logging and fires; type distribution was greatly altered. Today the spruce-fir type covers about 10 million acres, natural pine stands about 2½ million acres, and planted pine nearly 2 million. In addition, a large part of the 18 million acres of aspen-birch type is mature with an understory of balsam fir, which will eventually be the dominant species. In many localities, the fires have resulted in large contiguous acreages of one timber type such as jack pine.

Coniferous forests such as these — contiguous even-aged stands of one species or in a mixture of spruce and balsam fir — are especially vulnerable to insect attack. Defoliators, such as the spruce budworm and the larch sawfly, have periodically increased in abundance over the past several decades and have caused widespread tree mortality and reduction in growth. The budworm is again threatening thousands of acres of spruce-fir.

This paper presents the latest information for identifying the more important insect pests of conifers in this region. A key provides an additional guide. Some brief notes on life history and habits are also given for each insect. In general this information should serve adequately for identifying the common pests. Occasionally positive identification of some species may require a detailed examination by an expert.

A few species causing damage in areas adjacent to the Lake States, but not yet found in this area so far as is known, are also discussed.

KEY BASED ON TYPE OF INJURY

Each species of insect has certain characteristics which identify and differentiate it from all other insect species. These characteristics usually describe the appearance of the insect in its various stages of development or the kind of damage caused by feeding.

The following key is based almost entirely on feeding damage. To use it, the land manager studies the damage he has found in the tree, then systematically follows the key until he has found an appropriate description.

For the benefit of those not acquainted with the use of such a key, an example follows:

Assume that a jack pine tree is found with pitch blisters at the junction of small shoots. Item 1 in the key shows that all damage is divided into two groups: (1) foliage affected directly and (2) buds, terminals, branches, stems, or roots affected. In our example, shoots are damaged, which leads us to item 13 in the key.

Item 13 again gives us two choices (1) buds or shoots attacked, or (2) branches, trunk, or roots attacked. We are concerned with shoots, so we refer to item 14 as instructed by the key.

The first part of item 14 states that buds or shoots of terminals and laterals are injured. The alternative selection involves only fully developed terminals, so this could not be the correct choice. The first choice is thus selected, which refers us to number 15.

Number 15 also has two choices — the first describes damage to buds of red and Scotch pines, while the second choice again refers to damage to shoots, terminals, or branches of hard pines. This is the correct choice, so we are referred to number 16.

Number 16 again has two choices. The first describes the damage that we are examining; i.e., pitch blisters over galleries at junctions of small twigs or at nodes. The alternate choice is that a pitch blister is not formed, so the first choice is correct which directs us to the pitch-nodule maker. This is the insect responsible for the damage. According to the key, the pitch-nodule maker and its damage to trees is briefly described on page 25.

A few terms that may not be familiar to all readers are defined:

Adventitious — refers here to buds, leaves, or shoots that occur in unusual or abnormal places.

Axillary — in the crotch or angle of origin of two bodies such as twigs or branches.

Galleries — tunnels or burrows in wood or bark chewed by bark beetles or other wood-boring insects.

Larva — a young insect, which differs greatly in form from the adult. A caterpillar is an example. *Larvae* is the plural form of the word.

Nymph — a young immature insect closely resembling the adult but lacking wings.

Pupa — a stage between the larval and adult stages. This form is usually inactive.

Staminate — describes the male flowers of a plant, which have stamens but not pistils.

1. Foliage affected directly. 2
   Buds, terminals, branches, stems, or roots affected. 13

2. Foliage eaten. 3
   Foliage injured but not eaten. 10

3. Foliage of most species entirely consumed (page 7) .....SAWFLIES AND WEBWORMS
   Foliage mined or chewed off at needle sheath. 4

4. Foliage mined. 5
   Foliage clipped or chewed off at base. 7

5. Tamarack foliage as it develops in the spring mined by small caterpillars (page 10) .....LARCH CASEBEARER
   Spruce and pine foliage mined by small caterpillars. 6

6. Spruce foliage mined and lightly webbed together in small groups, becoming noticeable on the previous season's foliage in the spring when growth begins (page 10) .....SPRUCE NEEDLE MINERS
   Pine foliage mined but not webbed together. Fading becomes noticeable in the spring (page 11) .....PINE NEEDLE MINERS

7. Foliage clipped off at base and loosely webbed. 8
   Foliage chewed off at needle sheath. 9

8. Caterpillars, sparsely hairy; in early stages mining in the needles and buds or feeding in the staminate flowers of balsam fir, spruces, and pines; in later stages seen in clusters of needles clipped off at base and webbed together (page 11) .....SPRUCE BUDWORM
   JACK-PINE BUDWORM

9. Beetles chew developing foliage to needle sheath. Needle growth late in season is short and trees appear ragged. Old foliage is eaten when new foliage is not available. Various pines, jack pine preferred. At present known only in Lower Michigan in the Lake States (page 13) .....PINE CHAFER
   Caterpillars feed in staminate flowers of jack pine early in spring, then eat foliage to needle sheath, leaving a short stub. Caterpillars distinguished by four tufts of hair on the back (page 13) .....PINE TUSSOCK MOTH

10. Sucking insects attacking spruce foliage; pineapple-like axillary galls or cone-like terminal galls on current year's growth, formed

by enlargement of the basal portions of needles (page 16) ..... SPRUCE GALL APHIDS
Sucking insects attacking pine foliage; heavy infestation causes yellowing or spotting of needles. 11

11. New foliage of white pine covered with small black insects in late spring or early summer. Alternate generation in red cone-like galls on black spruce (page 17) ..... PINE LEAF APHID
Foliage of pine appears to be covered with scales. 12

12. Scales are elongate and white. Spruces sometimes attacked also (page 14) ..... PINE NEEDLE SCALE
Scales are oval and yellowish-brown to black in general color (page 15) ..... BLACK PINE LEAF SCALE

13. Buds or shoots attacked. 14
Branches, trunk, or roots attacked. 20

14. Buds or shoots of terminals and laterals injured; small caterpillars in buds or pith of shoots or in galleries covered by pitch masses. 15
Fully developed terminals affected. 19

15. Damage to buds and developing shoots of red pine and Scotch pine, becoming apparent in late April; buds hollowed out, and developing shoots crooked and often with pupal cases protruding. Two or more caterpillars per bud or shoot (page 24) ..... EUROPEAN PINE SHOOT MOTH
Damage to shoots, terminals, or branches of hard pines. 16

16. Pitch blister over gallery at junction of small twigs or at node (page 25) ..... PITCH NODULE MAKER
Pitch blister not formed. 17

17. Injury usually noticeable near wounds in a terminal or branch, caterpillars developing singly. Pines of all ages and heights attacked (page 25) ..... ZIMMERMAN PINE MOTH
Injury on tips of terminals and branches, more than one caterpillar present. 18

18. Hard pines up to 25 feet in height attacked; damage to terminals and branches noticeable by midsummer. Usually several caterpillars mining downward in the pith; dead shoot is brittle and breaks off (page 26).

WESTERN PINE TIP MOTH (*Rhyacionia frustrana* var. *bushnelli*)
Red, jack, and Scotch pines under 3 feet in height attacked. Damage first noticed when new growth is about 2 inches long, becoming

more noticeable as caterpillars tunnel and riddle the entire shoot, which is brittle and breaks under pressure (page 27) .....PINE TIP MOTH (*Rhyacionia adana*)

19. All pines and spruces attacked. Two or more years' growth killed (on jack pine often only one year). New growth wilts in May-June, is dead and brown by July-August. Legless, white larvae between bark and wood, working downward in a ring or, in later stages, in the pith (page 29) .....WHITE-PINE WEEVIL
Current year's growth of jack pine killed. Caterpillar bores down the pith and girdles the tip 3 to 6 inches above the node. The tip bends over, often breaking off and leaving a stub (page 27) .....JACK-PINE SHOOT BORER

20. Branches attacked. 21
Trunk or roots attacked. 25

21. Twigs of red pine ¼ to ¾ inch in diameter with gall-like swellings, often several on one twig. Emergence holes 1/16 inch in diameter (page 33) .....PINE GALL WEEVIL
Yellowish or reddish foliage first indication of attack. 22

22. Twigs swollen or twisted or with gall-like formations. 23
Branches attacked by sucking insects. 24

23. Semifluid resinous exudation around branch wounds on jack pine; small yellowish-orange larvae in resin (page 22) .....PINE MIDGES
Small galls formed by reddish-orange larvae in shoot at needle bases of spruce (page 23) .....SPRUCE GALL MIDGE

24. Bark surface normal, slightly knobby. When bark is peeled, surface of sapwood shows minute punctures surrounded by brown stain and blocked with coagulated resin. Injury on all pine species by adults or nymphs from May to September. Nymphs of the Saratoga spittlebug feed at base of undergrowth such as sweetfern, Rubus species, etc. (page 19) .....SPITTLEBUGS
Injury indicated by a sooty formation on foliage and small twigs of various hard pines. Oval brown female scales and glistening, silvery, empty male pupal cases are conspicuous in late spring and early summer (page 14) .....PINE TORTOISE SCALE

25. Main part of trunk attacked. 26
Base of trunk, root collar, or roots attacked. 31

26. Pitch masses at point of attack. 27
Pitch masses not formed. 28

27. Point of attack usually near a wound or just below a branch. Mass of pitch often 2 inches in diameter formed over gallery. On pines or spruces (page 28) ..... PITCH MASS BORER
Point of attack near a wound, several inches wide and long or larger, honeycombed with tunnels by several caterpillars. Trunk of pines covered with a mass of pitch (page 25) .... ZIMMERMAN PINE MOTH

28. Tunnelling on surface of wood or in the sapwood. 29
Bark surface covered with white cottony masses. 30

29. Inner bark and surface of wood often marked with winding galleries caused by small, legless, white larvae. Attack usually on weakened saplings or larger trees, especially those adjacent to cutting operations or windthrow. All conifers (page 34) ..... BARK BEETLES
Large tunnels in sapwood — sometimes into heartwood — of weakened trees or logs left in the woods. All conifers (page 35) ..... WOOD BORERS

30. Bark surface appears as if whitewashed, especially in well-shaded areas. Cottony masses sometimes at bases of needle clusters. Purplish to yellow soft-bodied insects in these masses. Usually on white, but sometimes on red pine (page 18) ..... PINE BARK APHID

31. Base of trunk or root collar attacked. 32
Roots attacked. 35

32. Small saplings and poles attacked. 33
Seedlings and transplants or reproduction attacked. 34

33. Tunneling in pines by small, legless, white larvae in wood at base of trunk. First indication of injury is unhealthy appearance of entire tree; with current season's growth often short (page 30) ..... NORTHERN PINE WEEVIL
Root collar with large gallaries in outer layers of wood. Soil around attacked portions infiltrated with resin. Injury is chiefly on sapling pines on sandy soils (page 31) ..... PINE ROOT COLLAR WEEVIL

34. Base of pine seedlings, transplants, or young reproduction girdled by feeding adult weevils. Injury during first and second growing season after cutting operations (page 32) ..... PALES WEEVIL

35. Roots of conifer seedlings and transplants severed or girdled below the ground line by larvae of June beetles. Damage in nurseries or in heavily sodded land (page 36) ..... WHITE GRUBS
Bark of conifer seedlings in nurseries eaten from the main stem and roots from the surface of the ground to a depth of several inches by larvae of weevils (page 33) ..... STRAWBERRY ROOT WEEVIL
BLACK VINE WEEVIL

Generally the loss of foliage due to feeding is the most noticeable form of insect injury. The seriousness of tree injury depends on the frequency of attack and the amount of defoliation. With the exception of tamarack, one complete defoliation will kill a conifer in the Lake States forests. Heavy defoliation also reduces radial increment; the impact of this in itself, even if mortality does not result, causes serious wood losses. Types of defoliation vary: The sawflies consume the entire needle whereas the needle miners and the budworms feed on only a part of it.

Sawflies

The group of insects collectively called sawflies contains some very destructive species, such as the red-headed pine sawfly and the larch sawfly (fig. 1). All the pines and spruces, balsam fir, tamarack, and introduced larches in the Lake States are subject to attack. Although sawflies attack hemlock, cedar, and juniper in other parts of the United States, there are no records of serious damage in this region. Since the particular species infesting a stand must be identified to determine correct timing of control operations, a chart has been prepared for 15 of the most common and most important species. The chart, which appears in the centerfold of this booklet, shows: the markings of the full-grown larvae, principal hosts, larval feeding period, feeding habits, and overwintering stage and location.

The information below applies to the sawflies as a group.

Hosts and range. — All conifers, except hemlock, cedar, and juniper, in natural stands and plantations throughout the Lake States.

Injury. — As the larvae feed on the foliage, singly or in groups, the tree assumes a ragged appearance. Some species attack only the new needles, some only the old. A few, like the larch sawfly, can denude an entire branch in a short time (fig. 2). One complete defoliation will kill any conifer except tamarack (fig. 3). Closer examination of a tree during the feeding period will show larvae at work, needles in various

F-485946

FIGURE 1. — A female larch sawfly laying eggs in a developing tamarack shoot.

F-485950

FIGURE 2. — Mature larch sawfly larvae on a tamarack twig. A group like this will destroy all the foliage on a branch in a short time.

F-501796

FIGURE 3. — A white pine completely stripped by the introduced pine sawfly. Defoliation like this may kill a tree in one season. Note the mature cones remaining.

stages of consumption, and some needles broken. Some species, like the red-headed pine sawfly, prefer the old needles but will eat the new needles and also the tender bark of the new twigs in the summer (fig. 4). Most of the sawfly species feed in the open and devour the needles entirely.

The larvae of the pine false web-

F-501797

FIGURE 4. — Severe feeding damage on red pine by the red-headed pine sawfly. This species prefers the old needles, but will eat the new needles and the tender bark on the new twigs.

FIGURE 5. — Left, the web formed by the larvae of the pine false webworm; right, the web formed by the caterpillars of the pine webworm. (Photos courtesy of the Connecticut Agricultural Experiment Station.)

worm and the nesting pine sawfly, however, develop in webs or nests (fig. 5). Similar webbing is formed by the true pine webworms — the caterpillars of the moth, *Tetralopha robustella* (fig. 5). These three species normally do not cause heavy damage; they are mentioned so that evidence of attack will be recognized if it should be found.

Description. —The adults of many of the species resemble small wasps or bees. The name "sawfly" is derived from the female egg-laying structure, which acts like a saw when used to form a slit in which an egg is deposited. A series of eggs in a pine needle looks like a row of small, yellow beads (fig. 6). Two of the species, the pine false webworm and the nesting pine sawfly, differ from the others in that they lay eggs on the needles rather than in them. The larvae are hairless and, when full grown, are about 1 inch long. They have three pairs of true legs on the thoracic segments and several pairs of pro-legs on the body segments. (See centerfold chart for details.)

F-501798
FIGURE 6.—Several series of sawfly eggs in pine needles. Each light-colored, half - moon - shaped slit contains an egg.

Needle Miners

The caterpillars of several species of moths mine the needles of Lake States conifers. The larch casebearer, which mines the tamarack foliage, is probably the most important species, as repeated attacks will kill trees. However, the spruces and pines are also attacked by various needle miners, and sometimes the damage is noticeable.

Larch Casebearer (Coleophora laricella)

Hosts and range. — Native tamarack and European larch. Of European origin, the larch casebearer was first recorded in Massachusetts in 1886. It has spread westward and is now well established in the Lake States.

Injury. — As the name implies, the caterpillar develops in a small cigar-shaped case, which is part of a mined needle lined with silk. While developing, each caterpillar mines several needles. It hibernates in the small case attached to a twig or branch. The heaviest damage occurs in the spring; with expansion of the buds the caterpillar resumes its leaf mining activity. As the foliage develops it shrivels, and when heavy feeding occurs the trees appear to have suffered frost damage. Under these conditions tree growth is retarded, and 2 or more years of heavy defoliation can kill trees.

Description. — The adult is a small, silvery-gray moth, with narrow wings fringed with long hairs. It has a wing spread of about three-eighths of an inch. The full-grown caterpillar is brown, with a black head, and is about three-sixteenths of an inch long.

Spruce Needle Miner (Evagora piceaella, Epinotia nanana, Taniva albolineana)

Hosts and range. — Native and introduced spruces throughout the Lake States.

Injury. — Although the spruce

needle miners are usually considered as pests of ornamentals, they sometimes cause serious needle destruction in spruce stands. The moths appear in late May or early June and lay their eggs on the old needles. After hatching, each of the young caterpillars mines several needles. By early fall silken webs of dead needles and frass are woven. Hibernation takes place in the webs or in mined needles. Feeding is resumed in the spring for a short time and new webs (fig. 7) are made in which the caterpillars pupate. Small groups of the needles become red or gray and drop off after several weeks.

Description. — The moths are grayish or brownish, depending on the species, and have a wing spread of about three-eighths of an inch. When full grown, the caterpillars are brownish and are one-quarter to five-sixteenths of an inch long.

Pine Needle Miners

A native species, *Exoteleia pinifoliella*, is commonly found on jack pine in the Lake States. In other parts of the country other hard pines are attacked, shortleaf pine being a favored host in the southern part of the North Central region. The mined needles are grayish or yellowish at the point of feeding. Each caterpillar mines several needles and hibernates in the last one mined. In the spring when tree growth begins, one or more additional needles are mined. Pupation takes place in a needle lined with silk in late May or early June. The full-grown caterpillars are about three-eighths of an inch long.

Budworms

Spruce Budworm (Choristoneura fumiferana)

Hosts and range. — Balsam fir, white spruce, and black spruce in

F-501799

FIGURE 7. — The webbing formed by one of the spruce needle miners. The light - colored needles in the center foreground have been mined and are a brownish color.

the spruce-fir types and balsam fir where it occurs as the understory in the aspen-birch types in the northern part of the Lake States.

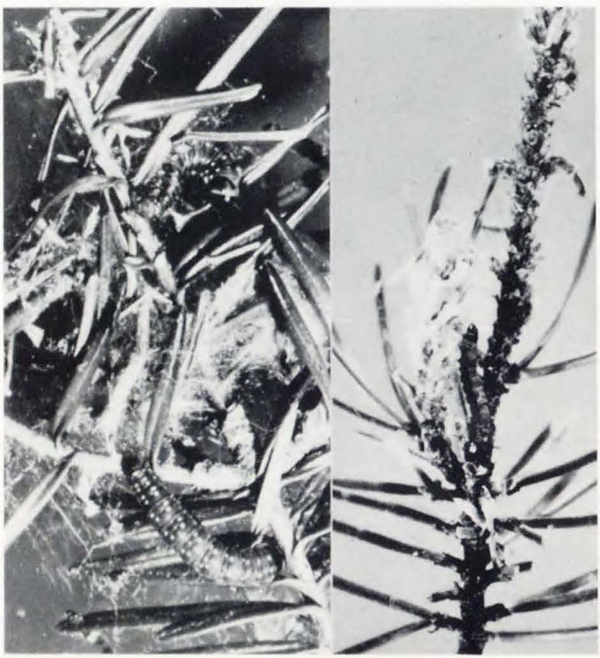
Injury. — Feeding begins in the spring with bud swelling. When an abundance of staminate flowers is present, much of the early feeding is in them; otherwise the old needles and the expanding buds are mined. As the new foliage develops, the later-stage caterpillars clip the needles at the base and spin a loose protective covering of silk and needle particles in which they later pupate (fig. 8). Heavy feeding makes the trees look brown or burned, and after several years' defoliation they appear gray. At intervals of approximately 35 to 50 years this insect develops to epidemic proportions, and heavy mortality, particularly of balsam fir, occurs in the mature stands.

Description. — The moths are generally of a grayish tinge, with a wingspread of about 1 inch. The young budworms are brownish; as they grow older they are reddish-brown to dark brown, with light yellow tubercles tipped with hairs. When full grown they are nearly an inch long.

Jack-Pine Budworm (Choristoneura pinus)

Hosts and range. — Jack pine is the preferred host, but red pine and white pine in the understory may be heavily defoliated by the late-stage larvae dropping down from the dominant jack pine. This insect is found throughout the range of jack pine in the Lake States.

Injury. — The early-stage larvae are very largely dependent on the staminate flowers for their early development. If the pollen does not ripen quickly, many of the larvae may complete the greater part of their development in the flowers. Otherwise the feeding habits on the foliage are similar to those of the



F-501800 and 501801
FIGURE 8. — Budworm feeding on (left) balsam fir foliage, (right) jack pine foliage. The foliage is chewed off at the base and tied together in a light web.

spruce budworm (fig. 8). Although infestations sometimes build up to damaging proportions in young pole stands, this species normally develops to epidemic status in open-growing "orchard-type" jack pine stands where there is an abundance of staminate flowers annually.

Description. —The moths are generally of a reddish tinge, with a wingspread of about 1 inch. In the early stage the larvae are yellowish-green; they are very similar to the spruce budworms in the later stages and differences can be detected only by the expert.

Pine Chafer

Pine Chafer or Anomala Beetle (Anomala oblivia)

Hosts and range. — Jack pine is the preferred host; but red, white, and Scotch pines may be attacked. In the Lake States this insect is known only in Lower Michigan.

Injury. — Both natural and planted stands are attacked; the most severe injury occurs in pure stands. The adults feed mainly on the new needles from early June through July. When feeding begins, the tips of some of the needles are eaten as they push through the needle sheaths; later the needles are partly cut off at the outer end of the sheath, which causes them to bend over, turn brown, and cling to the sheath. The old foliage may be attacked when the new growth has been destroyed, and the dead brown needles give a heavily infested tree a scorched appearance.

Description. — The pine chafer is closely related to the June beetles. The adults range from one-fourth to three-eighths of an inch in length, the female being slightly larger than the male. The female is light brown, while the male has dark tan wing covers and a greenish-bronze head and pronotum. The larvae are typical white grubs, and are about three-eighths of an inch long when full grown.

Tussock Moth

Pine Tussock Moth (Dasychira plagiata)

Hosts and range. — Jack pine in the northern part of the Lake States.

Injury. — When activity is resumed in the spring, the young caterpillars feed in the staminate flowers and then on the new foliage as it develops. In the late larval stages old needles are also attacked, and in heavy infestations trees may be stripped of their foliage in a short time.

Description. — The moths are grayish-brown, with irregular lighter and darker stripes on the forewings; the wingspread is about 1½ inches. The larvae, on hatching about the first of August, are very dark brown. Later they are grayish-brown with tufts of grayish or brownish hairs on the back and two pencils of black hairs in front of the first tuft. The eggs are quite large and conspicuous (fig. 9).

FIGURE 9. — Pine tussock moth eggs on a jack pine twig. (Courtesy of the Wisconsin Conservation Department.)

SUCKING INSECTS

The sucking insects, as their name implies, remove the sap from the foliage or from the outer layers of wood on the twigs, branches, or stems. Withdrawal of large quantities of sap weakens the trees and also causes malformed growth or dead areas under the bark. These areas may also act as infection courts for disease organisms. Several groups of sucking insects are discussed in the following pages.

Scale Insects

The damage by the scale insects is chiefly due to desiccation. Some species attack the foliage, others the twigs, branches, or stems of various conifers. When heavy infestations develop, a considerable amount of tree mortality may result.

Pine Tortoise Scale (Toumeyella numismaticum)

Hosts and range. — Jack and Scotch pines are the favored hosts; red and Austrian pines are sometimes attacked. The insect is widely distributed through the Lake States.

Injury. — The heavy secretion of honeydew by the feeding immature insects causes the formation of a sooty mold and gives a dark, glistening appearance to the foliage. Ants feeding on the honeydew may be very numerous. Branch mortality or death of the entire tree may result, and in a heavy infestation many trees will die after 1 or 2 seasons of heavy attack.

Description. — The insect hibernates as an immature female scale on the twigs (fig. 10), and it looks similar to a very small tortoise or turtle. In the spring when the buds begin to swell, the females lay eggs,

FIGURE 10. — Immature, hibernating female pine tortoise scales clustered on a jack pine twig. (Photo courtesy of Canada Department of Agriculture.)

which hatch into crawlers. These feed for a short time, a white powdery substance forming on their margins. When full grown the males pupate; the most obvious evidence of their presence is the silvery, glistening puparia clustered in large numbers on the twigs (fig. 11). The female scales are immobile; development continues until late in the fall when they go into hibernation.

Pine Needle Scale (Phenacaspis pinifoliae)

Hosts and range. — Pines and spruces throughout the Lake States.

Injury. — This insect is more im-

FIGURE 11. — Heavy infestation by the pine tortoise scale causes twig and tree mortality. The large white insects shown are predaceous ladybird beetle larvae, which usually control the tortoise scale very effectively. The minute dots are empty male pupal cases. (Photo courtesy of University of Wisconsin.)

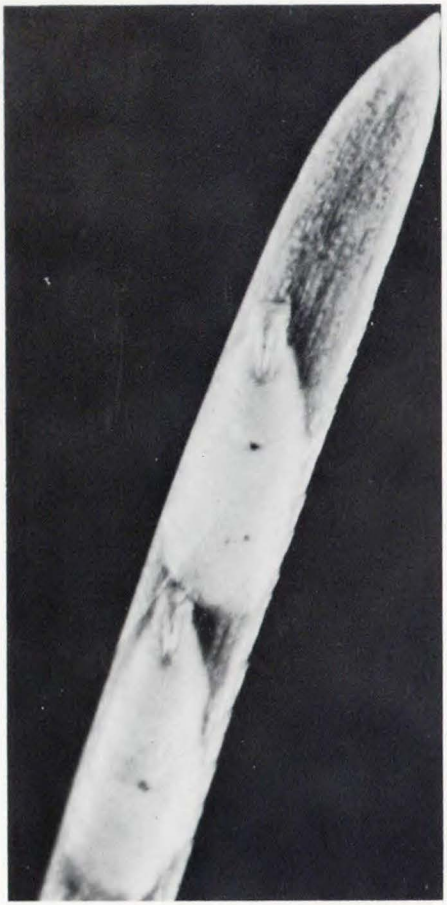
portant as a pest of ornamentals, but sometimes populations build up in forest stands and cause considerable injury. Presence of the scale may be recognized by the white excretion which covers the insect and gives the appearance of small white flecks on the individual needles (fig. 12). Heavy feeding reduces the sap content and causes a yellowing or spotting of the needles. A large population makes the entire tree appear gray.

Description. — This insect hibernates in the egg stage under the female scale, which is white, elongate, and about one-eighth of an inch long. Hatching begins in the spring about the time the new needles begin to develop. The reddish crawlers feed on these needles and mature in late July or early August; soon thereafter the adult females begin laying eggs.

Black Pine Leaf Scale (Aspidiotus californicus)

Hosts and range. — Various hard pines, jack pine being preferred, throughout the Lake States.

Injury. — The female scales pass the winter, half- to three-fourths grown, attached to the needles. They mature in the spring and lay their eggs. The crawlers hatch in June, insert their beaks in the old needles and feed, causing desiccation and death of the infested needles. A second generation of crawlers appears in August and feeds on the needles of the current season, also causing desiccation and death.



F-501802

FIGURE 12. — Pine needle scales on a pine needle, greatly enlarged. Heavy infestations cause premature needle drop and sometimes tree mortality. Individual scales are about one-eighth of an inch long.

Description. — The mature female scales are ovate, with a small elevated nipple in the center (fig. 13). They vary from yellowish-brown to black and are about one-sixteenth of an inch in diameter. The crawlers are very small and dark.

Aphids

The aphids form another group of sucking insects and, like the scales, they suck the sap and cause desiccation and death of branches or entire trees. The foliage or the bark may be attacked. The habits of aphids are extremely variable. Detection is often dependent on some knowledge of the life cycle. For this reason, pertinent information is given for each species discussed.

Eastern Spruce Gall Aphid (Chermes abietis)

Hosts and range. —Norway spruce and white spruce are the favored hosts in the Lake States.

Injury. — This insect is not considered an important forest pest; it is mentioned primarily because of the damage that sometimes occurs in nursery and other windbreaks, and on ornamentals. The injury is characterized by pineapple-like galls at the base of the current year's growth (fig. 14). Early in the summer the galls are greenish, with red curved cross markings. Later they dry and crack open. Old galls on

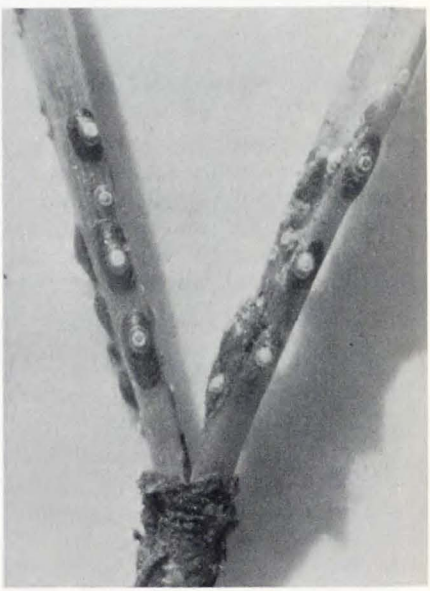


FIGURE 13. — The black pine leaf scale on jack pine. Heavy attacks may cause tree mortality. Individual scales are about one-sixteenth of an inch in diameter. (Photo courtesy of Wisconsin Conservation Department.)

FIGURE 14. — The pineapple-like gall formed by the spruce gall aphid at the base of the current year's growth. (Photo courtesy of the Connecticut Agricultural Experiment Station.)

the previous year's twigs are brown, with open cavities from which the developing aphids escaped. At least one-third of the trees in a stand will be resistant to attack, and vigorous attacked trees will recover.

Life history. — Only females of this species are known to occur. There are two generations annually, one of which hibernates in the nymphal stage. In the spring this form feeds briefly; when mature the insects are covered with white, fluffy, waxy hairs. Eggs are laid at the base of the buds; upon hatching, the new generation moves into the opening buds and begins to feed. Feeding by both forms stimulates the growing tissues and causes the formation of the galls. A winged form develops from the second generation; these adults fly to needles on the same or another spruce tree and deposit eggs which give rise to the hibernating generation.

Pine Leaf Aphid (Pineus pinifoliae)

Hosts and range. — White pine and black spruce in the Lake States.

Injury. — Two types of injury occur — one on the new foliage of

white pine, the other on the terminal shoots of the branches of black spruce. Damage to white pine is caused by the summer generation of nymphs and results in foliage desiccation and stunting of the twigs and branches. Periodically considerable damage has occurred on pine trees in local areas in the northern part of the Lake States. The alternate generation of nymphs causes reddish cone-like galls, about 1½ inches long, at the ends of black spruce twigs in June; they do not cause any appreciable damage, but they are objectionable on ornamentals.

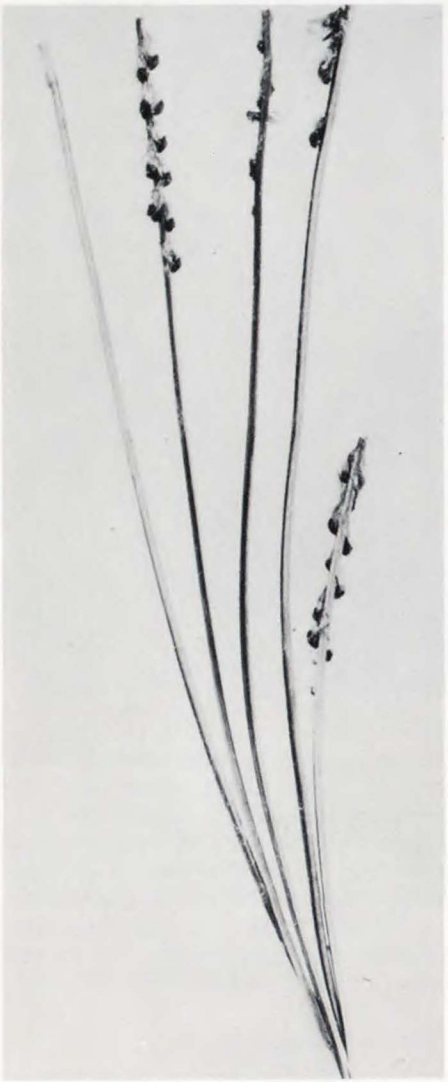


FIGURE 15. — The winged adults of the pine leaf aphid massed end to end on the needles of white pine. (Photo courtesy of the U.S. Northeastern Forest Experiment Station.)

Life history. — These insects overwinter as nymphs, covered with waxy cottony masses, on the white pine foliage. In the spring they transform to small black "flies," often massed end to end on the needles (fig. 15). Later they migrate to black spruce and lay eggs. The crawlers that emerge cause the terminal galls. A new generation of winged adults develops from these crawlers. They migrate to the white pines and lay eggs which hatch and give rise to the summer generation of nymphs. These nymphs feed on the pine needles until cold weather and then hibernate.

Pine Bark Aphid (Pineus strobi)

Hosts and range. — White, Scotch and Austrian pines wherever they occur in the Lake States.

Injury. — While all sizes of trees may be attacked, the most conspicuous damage occurs on nursery seedlings and small trees and ornamentals (fig. 16). A formation of cottony, waxy material may completely cover the larger branches and trunk and give the tree a whitewashed appearance. Heavy feeding will cause foliage discoloration, and large populations will stunt growth but rarely cause tree mortality.

Life history. — The immature females overwinter beneath the cottony masses. They mature in the spring and lay eggs. These hatch in 7 to 10 days and produce both wingless and winged forms. The wingless forms remain on the trees, while the winged forms migrate to nearby trees. Both forms secrete the cot-

FIGURE 16. — Pine bark aphid attack on the twigs of a white pine tree. Trees are not often killed, but heavy attacks may seriously affect the growth. (Photo courtesy of Wisconsin Conservation Department.)

tony masses. There may be several generations annually, particularly in the southern part of the range.

Spittlebugs

Two native species, the Saratoga spittlebug and the pine spittlebug, are common in the Lake States. Their feeding habits are somewhat different in that the nymphs of the former species develop on low growth such as sweetfern, while those of the latter develop on the pines.

Saratoga Spittlebug (Aphrophora saratogensis)

Hosts and range. — Red pine, jack pine, and occasionally white pine throughout the Lake States.

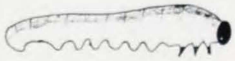
Injury. — This insect is one of the most important pests in plantations up to 15 feet in height. The nymphs develop in a spittle mass (fig. 17) at the ground line of a variety of low-growing plants; woody plants such as sweetfern and *Rubus* spp. are preferred, but heavy infestations occasionally develop where they are absent.

Injury to the pines is caused by the adults, which feed from about mid-July through September. The feeding has a threefold effect. The most serious is mechanical — blocking of the conducting tissue through resin infiltration around the feeding punctures. Secondly, when the adults are abundant a tremendous amount of sap is removed from a tree and causes what might be called starvation, especially under droughty conditions. A third effect, most commonly occurring on jack pine, is the invasion of injured tissue by the burn blight fungus, *Chilonectria cucurbitula*. Damage is usually noticeable the spring following heavy feeding and is characterized by red-foliaged branches and dead tops. The actual feeding injury can be detected by scraping the bark from the 2-year-old internodes and observing the characteristic brown feeding scars on the surface of the wood (fig. 18).

Description. — The adults are about three-eighths of an inch long and a light tan with paler cross markings. The eggs, which are

SAWFLIES ON CONIFERS

SPECIES	FULLY GROWN LARVAE	PRINCIPAL HOSTS	LARVAL FEEDING PERIOD (May, June, July, Aug., Sept.)	FEEDING HABITS	OVERWINTERING STAGE & LOCATION
Red-headed pine sawfly (Neodiprion lecontei)		Jack pine Red pine Scotch pine		Colonies; old foliage and tender bark.	Cocoon in topsoil or duff
White-pine sawfly (Neodiprion pinetum)		White pine		Colonies; old and current foliage	Cocoon in topsoil
Swaine jack-pine sawfly (Neodiprion swainei)		Jack pine		Colonies; old foliage primarily	Cocoon in topsoil
Introduced pine sawfly (Diprion similis)		White pine Jack pine		Singly; old and current foliage	Cocoon on twigs or in duff
Red-pine sawfly (Neodiprion nanulus nanulus)		Red pine Jack pine		Colonies; old foliage only	Eggs in slits in needles
European pine sawfly (Neodiprion sertifer)		Red pine Jack pine Scotch pine		Colonies; old foliage only	Eggs in slits in needles
Jack-pine sawfly (Neodiprion pratti banksianae)		Jack pine Red pine		Colonies; old foliage only	Eggs in slits in needles

Balsam-fir sawfly (Neodiprion abietis)		Balsam fir Spruces	Colonies	Eggs in slits in needles
A pine sawfly (Neodiprion maurus)		Jack pine	Colonies	Cocoon in the duff
A pine sawfly (Diprion frutetorum)		Red pine Scotch pine	Singly; old and current foliage	Cocoon on twigs or in duff
European spruce sawfly (Diprion hercyniae)		Spruces	Singly; old foliage preferred but may eat current	Cocoon in topsoil or duff
Yellow-headed spruce sawfly (Pikonema alaskensis)		Spruces	Semi-colonial; prefer old foliage first	Cocoon in soil
Larch sawfly (Pristiphora erichsonii)		Larches (=Tamarack)	Colonies	Cocoon in duff
Pine false webworm (Acantholyda erythrocephala)		Red pine White pine	Colonies; inside nest of webbed frass pellets	Larvae in cells in ground
Nesting pine sawfly (Acantholyda zappei)		Jack pine Red pine	Singly; inside nest of webbed frass pellets	Larvae in cells in ground

F-501803

FIGURE 17. — Spittle mass at base of sweetfern formed by nymphs of the Saratoga spittlebug. Several nymphs may be in one mass.

usually inserted between the scales of living terminal buds, are pale yellow to purple and are about one-sixteenth of an inch long. The first four nymphal stages have a scarlet abdomen, bordered by black at the sides, and a dark head and thorax. The fifth and last instar is dark brown throughout.

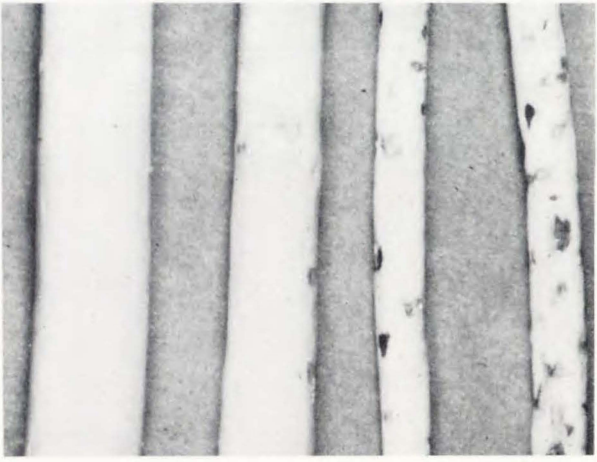
Pine Spittlebug (Aphrophora parallela)

The pine spittlebug is also fairly common in the Lake States. The adult is slightly larger and broader across the base of the wingcovers than the Saratoga spittlebug. The wingcovers are dotted with pale and dark spots, which appear as obscure transverse bands. Both the adults and the nymphs feed on the pines, but as a general rule populations are not sufficiently abundant to cause heavy damage. Occasionally, however, heavy infestations develop, and in such cases there is a continual drip from the spittle masses and a fine mist of undigested sap from the adults. Needles on heavily infested branches discolor and the twigs die. This condition progresses, and trees may be killed in 2 or 3 years.

Midges

Pitch Pine Midge (Retinodiplosis resinicola)

Hosts and range. — Jack pine growing on poor sites in the northern part of the Lake States. The closely related gouty pitch midge,



F-501804

FIGURE 18.—Brown spots or scars beneath the bark and on the surface of the wood indicate feeding by the Saratoga spittlebug adults; from left to right — no damage; and light, medium, and heavy damage. Branches vary from three-eighths to one-half inch in diameter.

F-501805

FIGURE 19. — Resin masses caused by feeding activity by the pine midge. This results in poor tree growth.

R. inopis, has been reported from Michigan and probably occurs elsewhere in the Lake States. Both species may be found on the same tree and at the same time.

Injury. — Resin masses (fig. 19), due to the feeding activities of the larvae, cause swollen or twisted twigs or branches. Several larvae may develop in each mass. Heavy feeding on slow-growing trees reduces the increment, particularly when an infestation continues for several years. Resin pockets form on older branches where attacks have healed. Infestations are generally spotty.

Description. — The adult midges are true flies, resembling mosquitoes in form. The larvae are yellow-orange to red small maggots.

Spruce Gall Midge (Phytophaga piceae)

Hosts and range. — The spruces in the Lake States.

Injury. — As a general rule attacks by this insect are confined to ornamental trees or individuals in a stand. Galls are formed on the twigs, producing a characteristic deformation (fig. 20). Heavily infested twigs may die. A secondary white fungus often follows the insect attack.

Description. —The adults are true flies, about one-eighth of an inch long. The reddish-orange larvae bore into the developing shoots in late May or early June and the galls become noticeable in about 10 days.

F-501806

FIGURE 20. — Gall formations on spruce twigs, caused by heavy spruce gall midge attacks, may kill the twigs.

BUD, SHOOT, STEM, AND ROOT INSECTS

Within the group of insects attacking bud, shoot, stem, and root are the caterpillars of several species of moths and the adults and larvae of a number of species of weevils and beetles. Trees in both natural and planted stands are subject to attack, and all parts of the tree from the terminals to the roots are injured. Each part may be attacked by more than one insect species. While tree mortality is not common, infested trees may be badly deformed. This degrades the trees and reduces the value of the stand or the finished wood product.

Caterpillars

European Pine Shoot Moth (Rhyacionia buoliana)

Hosts and range. — All pines may be attacked, but red pine suffers the greatest damage in the Lake States. Scotch pine is also favored. The insect is well established throughout southeastern Wisconsin, all of the Lower Peninsula, and parts of the Upper Peninsula of Michigan. It has not yet been found in Minnesota. The northern distribution in the Lake States is, in a large measure, limited by cold weather. Air temperatures lower than 20 degrees below zero Fahrenheit will kill the hibernating caterpillars above the snowline.

Injury. — The young caterpillars bore into the needle sheaths near the buds in July, causing a pitch formation. Very often a needle dies, turns brown, and is sufficiently conspicuous to indicate the location of an infested bud. The fourth-instar

F-501807

FIGURE 21. — Twisted bud development as a result of European pine shoot moth attack.

FIGURE 22. — A pitch blister formed by the pitch-nodule maker. Sometimes the shoot breaks off at the point of attack. (Photo courtesy of University of Wisconsin.)

caterpillars hibernate in the mined buds under a covering of pitch. With the beginning of shoot growth in the spring the developing buds are mined, and twisted growth results (fig. 21). In the advanced stage this damage is called a posthorn (cover picture). Commonly there may be two caterpillars in a single infested shoot; in heavy attacks there may be several. Under adverse growing conditions, heavily attacked trees are misshapen and stunted and the ultimate value of the stand will be reduced. Vigorous, fast-growing trees on a good soil will outgrow the injury.

Description. — The forewings of the moth are orange, marked with several irregular, silvery lines; the wingspread is about three-fourths of an inch. In the early stages the caterpillars are light brown; the color darkens as they grow older. When full grown, they are about three-fourths of an inch long.

Pitch-Nodule Maker or Pitch-Blister Moth (Petrova albicapitana)

Hosts and range. — Jack pine throughout the type range in the Lake States.

Injury. — A pitch blister forms on the young branches, generally at an internode or a fork (fig. 22). A single caterpillar develops under the pitch mass, which may be an inch or more in diameter, and destroys the wood almost to the pith. The attacked twig may be girdled and killed and sometimes breaks off at the point of attack.

Description. — The moths are reddish-brown with grayish patches on the forewings; the wingspread is about five-eighths of an inch. The caterpillar is light reddish-brown and, when full grown, is about half an inch long.

Zimmerman Pine Moth (Dioryctria zimmermani)

Hosts and range. — Most of the pines in the Lake States.

Injury. — Two types of injury are characteristic — one in the elongating shoots and one in the trunk. Shoot damage, indicated by an exudation of pitch and breakage at the point of attack (fig. 23), is very noticeable when the infestation is heavy. Trunk attacks are also conspicuous. At points of severe infestation a number of caterpillars will be

developing in and honeycombing one area. The stem will be enlarged and there will be an accumulation of pitch on the surface (fig. 24). Very often woodpeckers attack these areas, leaving holes where they searched for the caterpillars. This species and one closely related, *Dioryctria cambiicola,* cause tip damage to large red pines, and there is evidence that the attacks can affect the production of cones when the infestation is heavy.

Description. — The forewings of the moths are gray, and are marked transversely with zigzag lighter and darker lines. A reddish tinge may be present. The wing expanse is about 1 inch. The caterpillars are dirty white, reddish-yellow, or green, and are about 1 inch long when full grown.

F-492959

FIGURE 23. — Zimmerman pine moth injury to elongating shoots of Scotch pine. The fork or crook that often results reduces the timber value of the tree.

Western Pine Tip Moth (Rhyacionia frustrana variety bushnelli)

Hosts and range. — Young pines in the shelterbelts in the Northern Plains. The insect has been reported in western Minnesota, but this has not been confirmed. Most of the original infestations arose from the importation of seedlings from infested nurseries in the Plains. This insect is discussed here so that recognition may be possible if it becomes established in plantations in the Lake States.

Injury. — The injury is first noticed in the early summer when one or two dead needles may be found at the tip of the shoot. The young caterpillars feed in the buds, and when several caterpillars are present an entire bud may be destroyed. As they develop, the caterpillars bore into the center of the twig and follow down the pith. When the tip dies, adventitious buds grow from the living portion immediately below. In the northern part of the range there are two generations annually.

Description. — The forewings of the moths are reddish-brown with silver-gray markings. The wing expanse is about seven-sixteenths of an inch. The caterpillars are yellowish to pale brown and are about three-eighths of an inch long when full grown.

Other Tip Moths

The Nantucket pine tip moth, *Rhyacionia frustrana,* is a pest in nurseries and plantations in the southern part of the North Central Region. It is not known to occur in the Lake States. In habits and appearance the moths and caterpillars are similar to those of *bushnelli.*

F-492960

FIGURE 24. — Zimmerman pine moth injury to the main stem causes an enlargement of the bole, which is honeycombed beneath the pitch with numerous tunnels.

Another tip moth, *Rhyacionia adana,* which causes damage like that by the Western pine tip moth, has been reported recently in young pine plantations in Michigan. There is one generation a year. The young caterpillars mine the old needles at first and then enter the developing shoots after new needle growth has begun (fig. 25). Several caterpillars may bore in one shoot; growth of the insect continues until the shoot is tunneled and destroyed. The forewings of the moths are gray, with four pairs of grayish-white vertical bars. The wingspread is about five-eighths of an inch. The caterpillars are yellowish-brown to reddish-brown and when full grown are about five-sixteenths of an inch long.

Jack-Pine Shoot Borer (Eucosma sonomana)

Host and range. — Jack pine in the Lake States.

Injury. — This shoot-infesting insect kills the terminals of jack pine (fig. 26). Although attack has been noted on trees up to 30 feet in height, it usually occurs in young plantations on trees 3 to 12 feet high. The caterpillar bores into the pith, 6 to 8 inches above the branch whorl of the previous season, and mines downward for a few inches, then moving back up the shoot a short distance, it girdles the shoot, bores to the surface, and drops to the ground to pupate. By this time (about mid-July) the shoot has wilted and has bent over or broken off. But for the remaining stub and the absence of exit holes, this injury could be mistaken for that caused by the white-pine weevil.

Description. — The forewings of the moths are coppery red, and the wingspread is about three-fourths of an inch. The caterpillars are a brownish-gray and are about half an inch long when full grown.

FIGURE 25. — Developing shoot of red pine attacked by the pine tip moth, *Rhyacionia adana*. The needle indicates the point of attack. Note the shortened needle growth above the pinpoint. (Photo courtesy of the Michigan Department of Conservation.)

Pitch Mass Borer (Vespamima pini)

Hosts and range. — White pine is the preferred host, but other pines and spruces are attacked throughout the Lake States.

Injury. — This boring insect, like the Zimmerman pine moth, attacks the trunk of a tree near a wound or just below a branch (fig. 27). The pitch mass is much larger, however, often being 3 or 4 inches in diameter. The gallery, which is more or less transverse and winding, is made in the inner bark and the sapwood. Development of the insects takes 2 to 3 years. Although trees are not killed, some lumber degrade may result.

Description. — The forewings of the moth are blue-black, with a metallic green luster. The wing expanse is 1 to 1¼ inches. The caterpillars are white to pink, and are about 1¼ inches long when full grown. An empty pupal case, sticking out of the pitch mass, is a means of identification of this insect.

Weevils

Six species of weevils, or snout beetles, are among the more important insect pests of conifers in the Lake States. Almost all the pines and spruces, native and exotic as well as natural and planted, are subject to attack by one or more species of weevils, and all parts of the tree from the feeding roots to the leading shoots and the buds may be damaged.

White-Pine Weevil (Pissodes strobi)

Hosts and range. — White pine, jack pine, and Norway spruce are the preferred hosts, although other pines and spruces, growing naturally or planted, are attacked. Weeviling of red pine, formerly considered a rarity, is now common in portions of the Lake States.

Injury. — The adults hibernate in the litter and duff beneath the trees. When activity is resumed in the spring, the first evidence of attack is the tiny glistening droplets of resin at feeding and egg punctures in the preceding year's terminal shoot.

F-492898

FIGURE 26. — Damage to current leader of jack pine by the jack-pine shoot borer. A crook or fork occurs at the node below each point of attack.

FIGURE 27. — Pitch mass made by the pitch mass borer at pruned branch of Austrian pine. Mass is about 3 inches in diameter. Note the empty pupal case at upper right of the pitch mass.

Feeding by the larvae causes the new growth to wilt and turn brown (fig. 28). Two years' growth is usually killed, often three, and occasionally four. Jack pine often loses only 1 year's growth because the eggs may be laid in the growth of the current season after woody tissue has been formed. In such cases the new laterals may not be killed. The larvae work downward in a ring, feeding on the inner bark and the surface of the wood as they girdle and kill the shoot. Pupation occurs in a chip cocoon on the surface of the wood or in the pith (fig. 29). The new generation of adults, appearing in late summer, feeds on the bark of the small twigs, sometimes girdling and killing them.

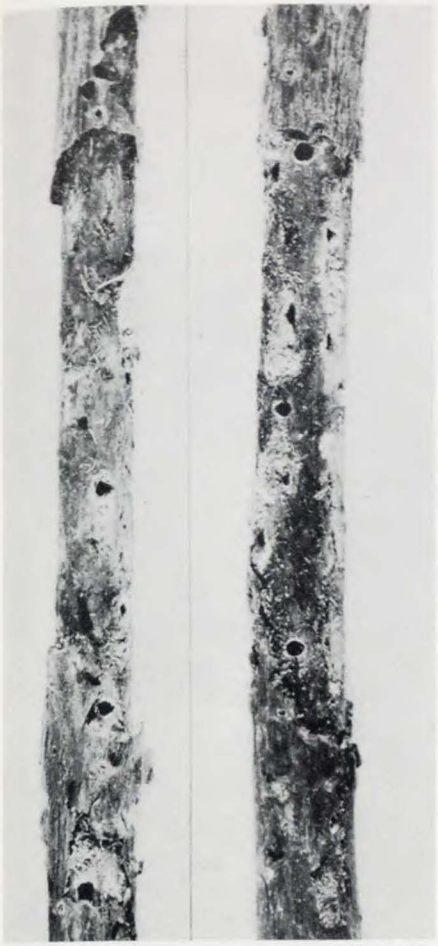
Description. — The adults are brownish, mottled with grayish-white and yellowish scales, and about one-fourth of an inch long. The larvae, which are legless white grubs, are slightly longer than the adults when full grown.

Northern Pine Weevil (Pissodes approximatus)

Hosts and range. — Pines in the northern part of the Lake States.

Injury. — Trees of all ages are attacked, but normally this weevil is found in weakened or dying trees. In recent years trees in young plantations in cutover areas have been successfully attacked by large populations which have built up in stumps cut the year before planting. In very young seedlings the larvae feed deeply, as the small diameter of the stems does not afford

F-500834
FIGURE 28. — A typical wilted terminal caused by successful white-pine weevil attack.



F-500835

FIGURE 29. — Chip cocoons and exit holes in terminals killed by the white-pine weevil.

sufficient space for development on the surface of the wood. When a large population develops on small saplings the entire trunk, large roots, and branches up to half an inch in diameter may be severely damaged, and in such cases tree mortality is common.

Description. — This insect very closely resembles the white-pine weevil in all its stages (see page 29). It differs in feeding habits, however, in that the chief damage is to the base and roots of small trees (fig. 30).

Pine Root Collar Weevil (Hylobius radicis)

Hosts and range. — Scotch, jack and red pines are the preferred hosts; white pine is rarely attacked. This insect is widely distributed throughout the Lake States, and is especially common in plantations on light soils.

Injury. — The stem and large roots are girdled just below the ground line (fig. 31). This feeding causes the foliage to turn yellow and then a deep reddish-brown. The faded trees, weakened at the ground line and leaning or broken, will be found scattered throughout a plantation. Such trees are almost certain evidence of attack by the pine root collar weevil. The adults feed on

FIGURE 30. — Larval tunnels and chip cocoons formed at the base of a young pine tree by the northern pine weevil. (Courtesy of Michigan State University.)

F-488104
FIGURE 31. — Evidence of attack by the pine root collar weevil at the base of a pine tree. Trees often break off at the point of attack.

the bark of the twigs and smaller branches in the fall of the year, and some twig mortality may occur.

Description. — The adults are about half an inch long and are dark red, brown, or black, with irregular light-colored patches. The white legless grubs are about half an inch long when full grown. Pupation takes place in a chamber of pitch and soil near the base of the attacked tree. All stages of development of the insect may be found throughout the year in the pitch-infiltrated soil.

Pales Weevil (Hylobius pales)

Hosts and range. — A pest in recently logged areas in the Lake States. White pine and red pine are the preferred hosts, although other conifer species may be attacked.

Injury. — The adults kill young seedlings by girdling them at the base (fig. 32) and by mining the buds. Feeding normally occurs at night or beneath the litter during the day, so it is not usually observed. Frequently damage is improperly identified as rodent feeding. The heaviest damage occurs in the fall of the year. Although tree mortality is usually restricted to natural seedlings or to transplants, the adults also feed on the twigs of branches of larger trees, and some twig mortality may occur. The eggs are laid and the larvae develop in freshly cut logs or stumps in June.

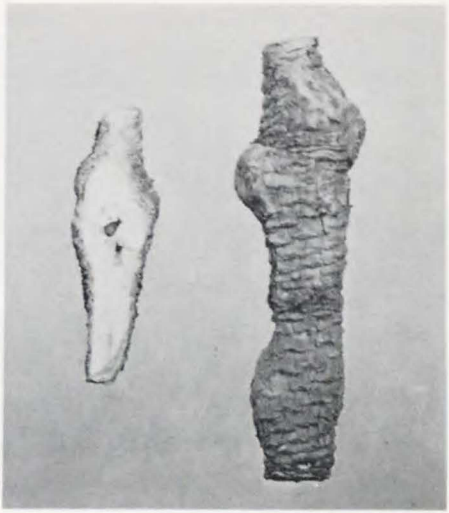
Description. — The adults are dark brown to black, marked irregularly and sparsely with small patches of gray or yellow hairs. They are three-eighths to one-half inch long. The larvae are white and legless, and are about half an inch long when full grown.

Pine Gall Weevil (Podapion gallicola)

Hosts and range. — Red pine in the Lake States.

Injury. — Woody spherical galls are formed on the twigs of red pine. The eggs are laid in June in the growth of the previous season and the galls become noticeable the following year. One or more larvae may develop in one gall, so the swelling may be small or it may appear as a large compound gall (fig. 33). When several galls are formed on a small branch, twig mortality can result.

FIGURE 32. — The appearance of the basal portion of a young pine seedling fed upon by the adult of the pales weevil. Note the severe girdling of the bark on the stem. (Photo courtesy U.S. Southeastern Forest Experiment Station.)



F-501808

FIGURE 33. — The gall formation on red pine twigs caused by the pine gall weevil. Heavy attacks will kill branches.

Description. — The adults are small black weevils, about three-sixteenths of an inch long. In common with the weevil group, the larvae are white and legless, and when full grown are slightly larger than the adults.

Strawberry Root Weevil (Brachyrhinus ovatus)

Hosts and range. — Conifer seedlings in all three Lake States.

Injury. — The larvae of this weevil feed on the roots of young conifers and at times serious losses occur in nursery beds. The injury is similar to that caused by white grubs: The fibrous roots are chewed off or the bark is stripped from the larger roots.

Description. — The adults are black and are about one-fourth of

an inch long. The larvae are slightly larger than the adults; they look like small white grubs, but they are legless.

Black Vine Weevil (Brachyrhinus sulcatus)

The black vine weevil, which is closely related to the strawberry root weevil and causes similar damage, may also be present in the Lake States. The adults are brownish-black, often speckled with white hairs, and about three-eighths of an inch long. The larvae are white and legless, and are slightly larger than the adults.

Bark Beetles

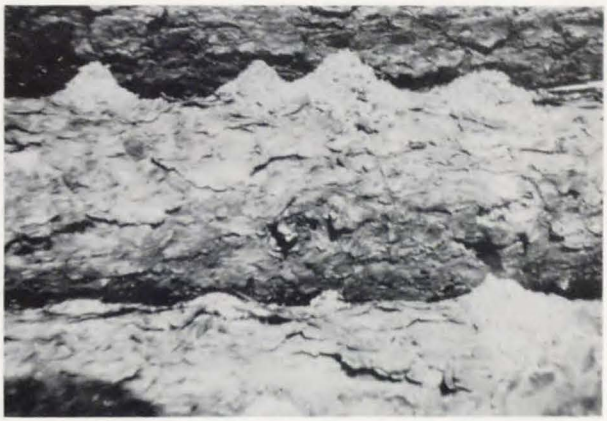
Hosts and range. — In the Lake States nearly all conifer species may be attacked by the various species of bark beetles. The insects, however, attack mostly weakened trees.

Injury. — Successful attack occurs only on those trees already weakened by defoliation, exposure, drought, fire, blowdown, or some other mechanical injury. During the spring and early summer, bark beetles may be attracted in large numbers to slashings left after logging. Under such circumstances young trees nearby may be heavily attacked and the less vigorous ones will die.

Trees attacked by two common species, *Ips pini* and *Pityogenes hopkinsi,* look unhealthy, the foliage being yellowish to red. In the early stages of attack a few entrance holes, often surrounded by hardened pitch, will be found in the bark. Later when the bark is removed, the larval galleries (fig. 34) will be apparent, etching the inner bark and the surface of the wood. Following surface burning in mature pine stands, the pitch tubes of the red turpentine beetle, *Dendroctonus valens,* may be found at the base of fire-scorched trees. This is an important species in the South and in the West, and is a potential danger in the Lake States under the conditions described above. Species of *Conophthorus, Pityophthorus,* and *Myeloborus* bore in the buds and tips of

F-501931

FIGURE 34. — Typical tunneling by bark beetle larvae; both the wood and the inner bark will be etched. Sometimes a pitch mass will be formed at the entrance hole made by the adult.



F-501809

FIGURE 35. — Piles of "sawdust" indicate tunneling in the wood by woodborers. The wood loss may be considerable.

pine branches and sometimes cause noticeable twig mortality.

Description. — The adults are small cylindrical beetles, ranging in color from reddish-brown to dark brown to black. The different species range in length from about one-eighth to three-eighths of an inch. The larvae are white and legless and have enlarged thoracic segments. Morphologically they closely resemble weevil larvae, but almost all species are smaller in comparable stages.

Woodborers

Hosts and range. —Pines, spruces, and balsam fir throughout the Lake States, particularly logs left in the woods during the spring and summer months, trees weakened by defoliators or exposure, and trees in blowdown areas.

Injury. — Galleries in the sapwood and sometimes in the heartwood are caused by the boring activities of the larvae of various species of roundheaded or long-horned borers and the flatheaded or metallic wood borers. There will be an appreciable loss of wood in pulpsticks, lumber may be degraded and structurally weakened, and the entrance and exit holes may serve as infection courts for woodrotting fungi. Development often takes 2 years. Piles of "sawdust" below logs (fig. 35) are a sure indication of borer attack. The adults also feed on the tender bark of small twigs, often causing red "flags." Feeding by the flatheaded borers is usually confined to the sapwood, the tunnels being tightly packed with frass.

Description. — The most important of the roundheaded borers are the sawyer beetles, *Monochamus scutellatus*, *M. notatus*, and *M. marmorator*; the last attacks balsam fir only. They are often called long-horned beetles because the antennae of the males may be two or three times longer than the body. The adults of *scutellatus* are black, sometimes mottled with white spots; those of *notatus* are gray, mottled with white spots; while those of *marmorator* are rust-red, mottled with yellow or creamy patches. The body size of all species varies from ¾ to 1¼ inches, the females averaging slightly larger than the males. The white elongate larvae are legless and are often more than 1½ inches long when full grown. Points of larval entrance into the wood and the tunnels are flattened or oval; the exit holes are round and are often more than ¼ inch in diameter.

The exit holes of the flatheaded borers, as well as the larval galleries, are flattened or oval. The adults are brownish to dull gold, with an iri-

descent sheen, and the antennae are much shorter than the body. The larvae are legless and white. The length, in general, is less than that for the roundheaded borers.

White Grubs

Hosts and range. — Nursery stock and seedlings and transplants of all conifers in planting areas in the Lake States.

Injury. — Destruction of the roots by the feeding larvae is the most important form of injury. Development to the adult stage requires 2 to 4 years, depending on the species and the latitude, so all larval stages may be present in any one area at one time. During the first year of development the feeding damage is slight. After hibernating deep in the soil, the larvae return to the upper soil layers and feed voraciously on the roots of various plants, including those of tree species. At least one more winter is spent in hibernation, after which the larvae come up to feed for a brief time before pupating. Newly planted seedlings and transplants are most severely affected. They exhibit typical symptoms of drought damage; pulling on them discloses that the root system has been damaged or completely cut off (fig. 36). Grassy fields surrounded by hardwood trees and shrubs are especially favorable for high white grub populations. The adult beetles feed on the leaves of these trees, cutting characteristic patterns in them. When fields and forest openings are planted with coniferous seedlings, white grub larvae often destroy the root systems of the small trees before the trees become established.

Description. — These insects are members of a number of genera of chafer beetles or June beetles. The adults vary in color from light brown to nearly black and in length from ¼ to nearly 1 inch. The larvae are milky white, with six prominent legs and brownish heads. Their bodies are strongly curved; the hind parts are shiny, with the body contents visible through the skin. They vary in length from ⅛ inch when hatched to more than 1 inch when full grown.

FIGURE 36. — Damage to roots of young seedlings by white grubs. Cutting off or girdling the roots causes death. Most severe damage on right. (Photo courtesy of the University of Wisconsin.)

INJURIOUS SPECIES NOT YET RECORDED

The conifer types in the Lake States are similar in general make-up to those of the remainder of the boreal forests in eastern Canada and the Northeastern States. Generally speaking, the insect pests are similar. However, a number of important species in these other forest areas are not known to occur in the Lake States. They are of great potential importance as some of them have caused heavy losses where they have built up to epidemic force. Forest managers and people making insect surveys should be alert to the possibility of finding these pests. Three of them are discussed below.

FIGURE 37. — Fluffy cottony masses covering the male cocoons of the red pine scale: (left), in the bark crevices on the trunk and larger branches; (right), at the needle bases on a twig. Heavy infestations kill trees. (Photo courtesy of the Connecticut Agricultural Experiment Station.)

Black-Headed Budworm (Acleris variana) . . . . . .

Hosts and range. — Balsam fir and spruce in Ontario and Northeastern United States. The insect also attacks several tree species in the West. The presence of the black-headed budworm in Minnesota has been shown on maps, but there are no authentic records of collections.

FIGURE 38. — Heavy stem attack of balsam fir by the balsam woolly aphid. This results in hard, brittle, discolored sapwood. (Photo courtesy Canada Department of Agriculture.)

Injury. — Feeding damage is similar to that by the spruce budworm: the needles are partially eaten and are loosely bound together in a web.

Description. — The forewings of the moths are predominantly mottled-gray, with various brown, white, or gray cross bands. The wingspread is about five-eighths of an inch. The young caterpillars are pale yellow, with black heads; when full grown they are yellow to green, with brown heads, and are about half an inch long.

Red Pine Scale (Matsucoccus resinosae)

Host and range. — Red pine in southwestern Connecticut and southeastern New York.

Injury. — All ages of trees from nursery stock to maturity are attacked. The first visible indication of attack is the olive-green color of the current season's foliage and shorter-than-normal twig growth. The foliage gradually changes color through yellow to red, first in individual branches and then through the entire crown. The bark on the branches of heavily infested trees will be swollen and cracked, and small fluffy cottony masses will be present (fig. 37). An area of dead woody tissue will be found under each feeding scale.

Description. — The adult females are brownish-red, wingless, and from one-sixteenth to three-sixteenths of an inch long. The preadult males resemble the females but are somewhat smaller. The true adult males are midge-like and two-winged. The larvae, as they develop, are nearly elliptical and are fringed with the fluffy cottony mass previously mentioned.

FIGURE 39. — The gout disease of balsam fir, caused by heavy feeding by the balsam woolly aphid, is characterized by rounded lumps at the ends of the twigs. (Photo courtesy Canada Department of Agriculture.)

Balsam Woolly Aphid (Adelges piceae)

Hosts and range. — Balsam fir in the Northeastern States and Fraser fir in the Southeastern States. Several species of firs are attacked in the far Western States.

Injury. — Two types of injury occur. The boles of the trees, when heavily attacked, have the same characteristic whitewashed appearance (fig. 38) typical of pine bark aphid attack (see page 18). The sapwood of attacked trees is hard, brittle, and discolored; the trees themselves are often of poor form and of low value for pulpwood because of the high lignin content. The second type of injury is swelling and distortion of the buds, twigs, and smaller branches (fig. 39) of all sizes of trees from seedlings to sawtimber. This injury is called gout disease.

Life history. — Although winged forms occasionally arise, this insect develops through two generations of wingless larvae or nymphs, called sistentes. One generation overwinters in bark crevices at the base of buds, on branches, or on the main stem. When tree growth begins in the spring these nymphs develop rapidly into females which lay eggs beneath the woolly masses covering them. The crawlers hatched from these eggs feed on the bark of the stem or the twigs, causing the two types of injury described. Eventually they develop into females, which lay eggs and give rise to the hibernating form.

BIBLIOGRAPHY

Anderson, Roger F.
1960. Forest and shade tree entomology. 428 pp., illus. John Wiley & Sons, Inc.

Bean, James L.
1956. Red pine scale. U.S. Forest Serv., Forest Pest Leaflet 10, 4 pp., illus.

Bean, J. L., and Waters, W. E.
1961. Spruce budworm in eastern United States. U.S. Forest Serv., Forest Pest Leaflet 58, 8 pp., illus.

Benjamin, Daniel M.
1955. The biology and ecology of the red-headed pine sawfly. U.S. Dept. Agr. Tech. Bul. 1188, 57 pp., illus.

Craighead, F. C.
1950. Insect enemies of eastern forests. U.S. Dept. Agr. Misc. Pub. 657, 679 pp., illus.

Drooz, Arnold T.
1956. The larch sawfly. U.S. Forest Serv., Forest Pest Leaflet 8, 4 pp., illus.

Drooz, A. T.
1960. The larch sawfly, its biology and control. U.S. Dept. Agri. Tech. Bul. 1212, 52 pp., illus.

Eaton, Charles B.
1955. The Saratoga spittlebug. U.S. Forest Serv., Forest Pest Leaflet 3, 4 pp., illus.

Eaton, C. B., and Yuill, J. S.
1960. Gouty pitch midge. U.S. Forest Serv., Forest Pest Leaflet 46, 8 pp., illus.

Ewan, Herbert G.
1957. The jack-pine sawfly. U.S. Forest Serv., Forest Pest Leaflet 17, 4 pp., illus.

Ewan, Herbert G.
1961. The Saratoga spittlebug — a destructive pest in red pine plantations. U.S. Dept. Agr. Tech. Bul. 1250, 52 pp., illus.

Jaynes, H. A., and MacAloney, H. J.
1958. White-pine weevil. U.S. Forest Serv., Forest Pest Leaflet 21, 7 pp., illus.

MacAloney, H. J.
1943. The white-pine weevil. U.S. Dept. Agri. Cir. 221 (revised), 31 pp., illus.

MacAloney, Harvey J.
1957. The red-headed pine sawfly. U.S. Forest Serv., Forest Pest Leaflet 14, 4 pp., illus.

MacAloney, Harvey J.
1961. The pine tortoise scale. U.S. Forest Serv., Forest Pest Leaflet 57, 4 pp., illus.

MacAloney, Harvey J., and Drooz, Arnold T.
1956. The jack-pine budworm. U.S. Forest Serv., Forest Pest Leaflet 7, 4 pp., illus.

McCambridge, W. F., and Downing, G. L.
1960. Black-headed budworm. U.S. Forest Serv., Forest Pest Leaflet 45, 4 pp., illus.

Miller, William E., and Neiswander, Ralph B.
1955. Biology and control of the European pine shoot moth. Ohio Agr. Expt. Sta. Res. Bul. 760, 31 pp., illus.

Miller, William E., and Neiswander, Ralph B.
1956. The pitch twig moth and its occurrence in Ohio. Ohio Agr. Expt. Sta. Res. Bul. 779, 24 pp., illus.

Miller, William E., Hastings, Arthur R., and Wootten, John F.
1961. European pine shoot moth. U.S. Forest Serv., Forest Pest Leaflet 59, 8 pp., illus.

Schmiege, D. C.
1959. Pine root collar weevil. U.S. Forest Service., Forest Pest Leaflet 39, 4 pp., illus.

Shenefelt, Roy D., and Benjamin, Daniel M.
1955. Insects of Wisconsin forests. Wis. Univ. Cir. 500, 110 pp., illus.

Smith, Richard H.
1961. Red turpentine beetle. U.S. Forest Serv., Forest Pest Leaflet 55, 8 pp., illus.

Speers, Charles F., and Schmiege, Donald C.
1961. White grubs in forest tree nurseries and plantations. U.S. Forest Serv., Forest Pest Leaflet 63, 4 pp., illus.

Talerico, Robert L.
1959. How to separate damage by the European pine shoot moth, the Zimmerman pine moth, and the pitch mass borer. U.S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 571, 2 pp., illus.

Yates, Harry O. III.
1960. The Nantucket pine moth, a literature review. U.S. Forest Serv., Southeastern Forest Expt. Sta., Sta. Paper 115, 17 pp., illus.

SOME RECENT STATION PAPERS

LAKE STATES FOREST EXPERIMENT STATION

Streambank Stabilization in Michigan — A Survey, by W. D. Striffler. Sta. Paper 84, 14 pp., illus. 1960.

Pulpwood Production in Lake States Counties, 1959, by Arthur G. Horn. Sta. Paper 85, 13 pp., illus. 1960.

Evaluating the Growth Potential of Aspen Lands in Northern Minnesota, by R. O. Strothmann. Sta. Paper 86, 20 pp., illus. 1960.

The Climatic Distribution of Blister Rust on White Pine in Wisconsin, by E. P. Van Arsdel, A. J. Riker, T. F. Kouba, V. E. Suomi, and R. A. Bryson. Sta. Paper 87, 34 pp., illus. 1961.

Forest Recreation in the Upper Great Lakes Area: Proceedings of a Seminar on Research Needs, May 11-13, 1961. Sta. Paper 89, 104 pp., illus. 1961.

Wisconsin's Forest Resources, by Robert N. Stone and Harry W. Thorne. Sta. Paper 90, 52 pp., illus. 1961.

Field Calibration of a Neutron-Scattering Soil Moisture Meter, by Richard S. Sartz and Willie R. Curtis. Sta. Paper 91, 15 pp., illus. 1961.

Growing White Pine in the Lake States to Avoid Blister Rust, by Eugene P. Van Arsdel. Sta. Paper 92, 11 pp., illus. 1961.

Farm Lumber Consumption and Use Data: Needs and Methods of Estimating, by Allen L. Lundgren and Ronald I. Beazley. Sta. Paper 93, 20 pp., illus. 1961.

Pulpwood Production in Lake States Counties, 1960, by Arthur G. Horn. Sta. Paper 94, 28 pp., illus. 1962.

Small Private Forest Landowners in Michigan's Upper Peninsula — Characteristics, Ownership Attitudes, and Forestry Practices, by Dean N. Quinney. Sta. Paper 95, 20 pp., illus. 1962.

Contracting for Forest Aerial Photography in the United States, by Gene Avery and Merle P. Meyer. Sta. Paper 96, 37 pp., illus. 1962.

Three Pine Release Experiments in Northern Minnesota, by Robert E. Buckman and Allen L. Lundgren. Sta. Paper 97, 9 pp., illus. 1962.

Proceedings of the Fifth Lake States Forest Tree Improvement Conference. Sta. Paper 98, 42 pp. 1962.

Growth Through Agricultural Progress